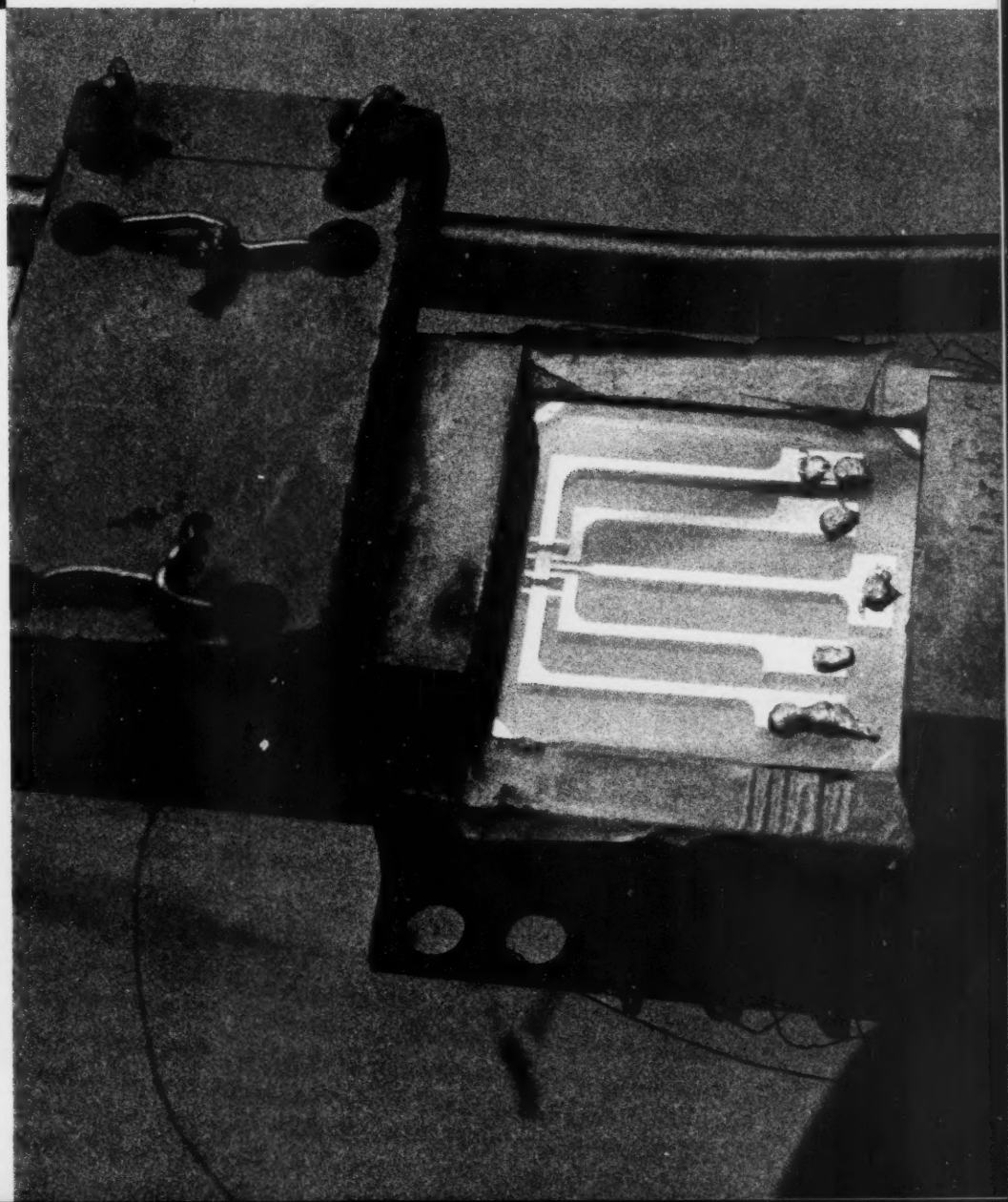
A UNITED STATES DEPARTMENT OF COMMERCE PUBLICATION

U. S. National Bureau of Standards

July 1972

NATIONAL BUREAU OF STANDARDS

Technical News Bulletin



UNITED STATES DEPARTMENT OF COMMERCE

NBSTAR 56(7)
157–176(1972)

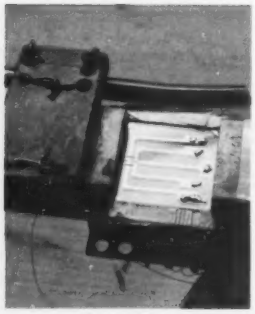
NATIONAL BUREAU OF STANDARDS
Technical News Bulletin
JULY 1972 / VOL. 56, NO. 7 / ISSUED MONTHLY

CONTENTS

Nat. Bur. Stand. (U.S.) Tech. News Bull.
CODEN : NBSTAR 56(7) 157–176 (1972)

Superintendent of Documents Catalog No. C13.13 : 56/7

Library of Congress Catalog No. 25–26527



Cover: Photograph of a Josephson tunnel junction mounted in a 10 GHz (X band) microwave waveguide. At NBS, such junctions are being used to maintain the U.S. legal volt. See page 159 for further details.

U.S. DEPARTMENT OF COMMERCE
Peter G. Peterson, Secretary

James H. Wakelin, Jr.
Assistant Secretary
for Science and Technology

NATIONAL BUREAU OF STANDARDS
Lawrence M. Kushner, Acting Director

Prepared by the NBS Office of Technical Information and Publications, Washington, D.C. 20234

W. R. Tilley, Chief

Managing Editor
D. V. Baker

Contributing Editors
L. K. Armstrong, R. T. Cook, D. K. Coyle, J. E. Kluge, C. R. Naas, A. Schach, C. N. Smith, S. A. Washburn, D. E. Webb

C. Messina, Visual Editor

The National Bureau of Standards serves as a focal point in the Federal Government for assuring maximum application of the physical and engineering sciences to the advancement of technology in industry and commerce. For this purpose, the Bureau is organized as follows:

The Institute for Basic Standards

The Institute for Materials Research

The Institute for Applied Technology

Center for Radiation Research

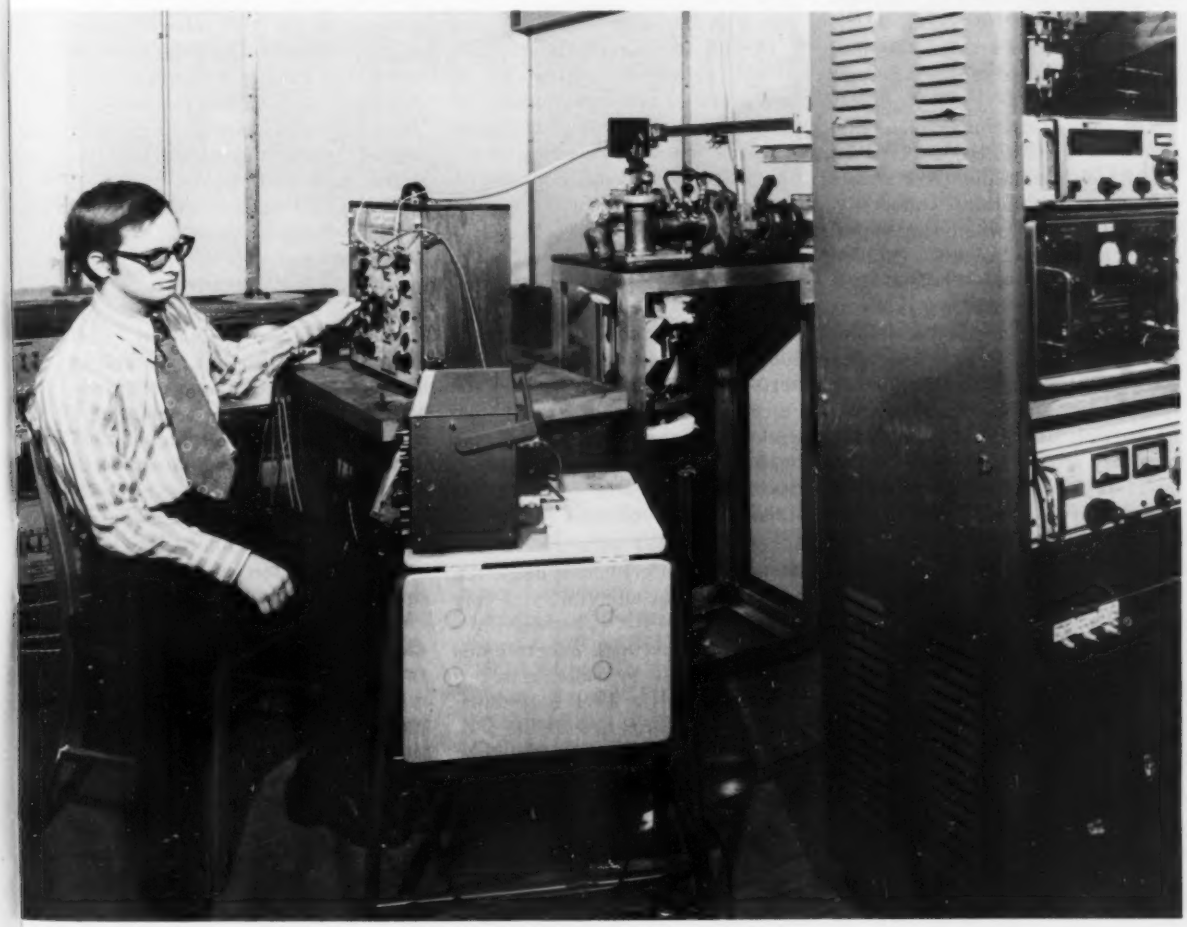
Center for Computer Sciences and Technology

The TECHNICAL NEWS BULLETIN is published to keep science and industry informed regarding the technical programs, accomplishments, and activities of NBS.

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Annual subscription: Domestic, $3; foreign, $4; single copy, 30 cents. Use of funds for printing this publication approved by the Director of the Office of Management and Budget (June 22, 1971).

NBS TO MAINTAIN U.S. LEGAL VOLT USING $2e/h$ VIA THE AC JOSEPHSON EFFECT

On July 1, 1972, the National Bureau of Standards, U.S. Department of Commerce, adopted a new procedure for maintaining the U.S. legal volt. The new method is based on the determination of the ratio of twice the electron charge to Planck's constant, $2e/h$, using the ac Josephson effect in superconductors. Recent work at NBS and elsewhere has shown that $2e/h$ can be determined in terms of a *particular* as-maintained unit of voltage to 1 part in 10 million or better. Since $2e/h$ is an invariant fundamental constant of nature, the Josephson effect provides, for the first time, a means for deriving a reproducible, invariant voltage.



Overall view of the apparatus employed at NBS to maintain the U.S. legal volt using measurements of 2e/h via the ac Josephson effect in superconductors. The microwave components are in the relay rack at the right, the 100:1 voltage comparator is being manipulated by the operator, and the Josephson junction is mounted in the cryostat in the center stand.

The new procedure will not affect the basic day-to-day maintenance and dissemination of the volt, but will merely change the basic premise of what is assumed to be constant. In the past, the U.S. legal volt has been defined by means of a large reference group of saturated standard cells maintained at constant temperature and for which the mean emf of the group is assumed constant with time. In reality, however, the mean emf drifts, perhaps as much as several parts in 10 million per year. As a result, the measured value of $2e/h$ appears to vary with time. Under the new procedure, the mean emf assigned to the reference group of cells will be adjusted periodically to eliminate the apparent variation of $2e/h$, thereby providing a significant improvement in the long term maintenance of the U.S. legal volt.

The ac Josephson effect, first predicted theoretically in 1962 by Brian Josephson, then a graduate student at Cambridge University, England, occurs when two superconductors are "weakly" coupled together and cooled below their transition temperature (usually a few kelvins). One method of obtaining the required weak coupling is to separate the two superconductors by a very thin (about 1 nm) insulating barrier, usually an oxide layer thermally grown on one of the superconductors. When a potential difference V is applied between the separated superconductors, electron pairs tunnel through the insulating barrier, generating an oscillating or ac "supercurrent" between the two superconductors. The frequency ν of this ac supercurrent is related to the applied voltage by the so-called Josephson frequency-voltage relation, $\nu = (2e/h)\,V$. The Josephson junction is therefore an ideal frequency to voltage converter since the constant of proportionality is the invariant fundamental physical constant $2e/h$. Furthermore, the frequency-voltage relation is essentially exact and independent of all experimental variables, including temperature, magnetic field, and type of superconductor used.

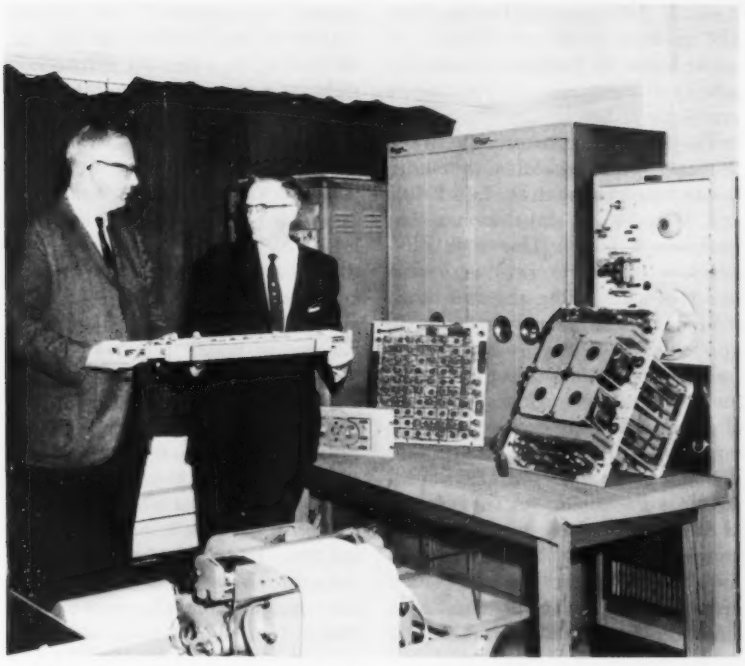
The Josephson device is used in practice by irradiating it with microwave radiation of frequency ν_o, usually of order 10 GHz (X band). This applied radiation interacts with the ac supercurrent, resulting in a current-voltage curve for the junction which displays constant voltage current steps. The nth step occurs at a voltage V_n which is related to the frequency of the applied radiation by $n\nu_o = (2e/h)V_n$. For 10 GHz radiation, each step is separated by about 20 μV and up to 250 well-defined steps may be observed, corresponding to a voltage of about 5 mV.

In the measurements at NBS, which are a continuation of the methods first pioneered at the University of Pennsylvania, two junctions are operated in series to give a total step voltage of about 10 mV. This voltage is then compared with the emf of a standard cell by means of a special 100:1 fixed ratio potentiometer utilizing two interchangeable Hamon networks. The latter permit the establishment of the 100:1 ratio to an accuracy of 1 or 2 parts in 10^8. By adjusting both the current through the Hamon networks and the frequency of the applied microwave radiation, it is possible to directly compare the standard-cell voltage (approximately 1.018 V) with the 10 mV (actually 10.18 mV) Josephson-step voltage with an uncertainty of only a few parts in 10^8. (Thermal emf's and Hamon network uncertainties are eliminated by suitable reversals.) Since July of 1971, determinations of $2e/h$ in terms of the U.S. legal volt have been made at about 2-week intervals. From these measurements, it has been concluded that the legal unit has decreased linearly over this period at the rate of about 0.03 μV per month. The actual value of $2e/h$ implied by these measurements as of July 1, 1972, and therefore the value adopted by NBS for use in maintaining the legal volt after this date, is $2e/h = 483.593420$ THz/V_{NBS}. Bureau scientists believe that the legal volt can be maintained consistent with this adopted exact number indefinitely to within 1 part in 10^7.

Other national laboratories are carrying out Josephson effect measurements of $2e/h$, including the National Physical Laboratory (NPL), United Kingdom; the National Standards Laboratory (NSL), Australia; and the Physikalisch-Technische Bundesanstalt (PTB), Germany. Recently, the values of $2e/h$ measured at these laboratories in terms of their respective as-maintained units of voltage were compared with the NBS value by means of a shippable, temperature-regulated, volt-transport standard. This standard enabled the relationships between the units of voltage maintained by the four national laboratories involved to be determined to within 1 to 2 parts in 10^7. Since the values of $2e/h$ obtained at these laboratories all agreed to within this amount (when converted to a common unit of voltage), it can be concluded that the Josephson effect measurements of $2e/h$ are well in hand and that serious consideration should be given to adopting a single international value of $2e/h$ for use in maintaining units of voltage.

It should be emphasized that in using $2e/h$ to maintain the U.S. legal volt, the Système International (SI) definition of the volt remains unchanged. That is, the Josephson effect is not being used to redefine the absolute volt but only as a means of better maintaining its physical embodiment. A redefinition of the SI volt in terms of $2e/h$ would require a rather comprehensive revision of the SI system and is not being contemplated at this time. (For further information, contact the Electricity Division, National Bureau of Standards.)

NBS AND THE DEVELOPMENT OF COMPUTER TECHNOLOGY



SEAC was retired in 1964, after 15 years of service. Some of its components were presented by then NBS Director Dr. A. V. Astin (right) to Dr. W. F. Cannon of the Smithsonian Institution for display in the Museum of Science and Technology.

At the dawn of the computer era, the National Bureau of Standards was a leader in developing America's first large-scale electronic computers. Today, a quarter-century later, NBS is providing technological leadership to help the Nation more effectively use its inventory of more than 88,000 computers.

In the 25 years since the first Electronic Numerical Integrater and Automatic Computer (ENIAC) was built at the University of Pennsylvania, computer technology has spawned an industry that is currently the eighth largest in the United States and is forecast to become the third largest by 1990. U.S. expenditures in 1970 for computer products, services, and operating staffs have been estimated at $20 to $25 billion.

With 61 percent of the world's inventory of some 144,000 computers, the United States currently has one computer for every 2,300 people or one for every 730 families. Computer resources, including some 500,000 computer programmers, operators and analysts, are distributed throughout the economy. The Federal Government has approximately 6.8 percent of U.S. computers; state and local governments and education have 11.2 percent; the financial community has 16 percent; health care, utilities, wholesale and retail trade, and ADP service firms account for 26 percent; and the manufacturing industries account for the remaining 40 percent. The number of different types of computer applications grew from more than 300 in 1960 to more than 2,000 in 1971.

The NBS involvement in the development of computer technology had its origin in the Bureau's World War II work on electron tubes, printed circuits, and miniaturization. The Bureau's first computer project was initiated in 1946 and was carried out in the Applied Mathematics and Electronics Divisions. Shortly afterward, the Bureau of the Census and the Office of Naval Research (ONR) asked NBS to prepare the design specifications and construct two full-scale computers. NBS contracted with the Eckert and Mauchley Electronic Control Co. for the Bureau of the Census computer and with the Raytheon Manufacturing Co. for the ONR computer. At the same time, work was initiated on the NBS Interim Computer which was to test components, train operators, and perform computational work for NBS laboratories. The Air Force Office of the Air Comptroller and the Army Map Service asked NBS to expand the contract with Eckert and Mauchley to include two more computers.

When it became apparent that there would be delays in delivery of the UNIVAC (Universal Automatic Computer) being built by Eckert and Mauchley, the Office of the Air

Contributed by M. Zane Thornton, Deputy Director, Center for Computer Sciences and Technology.

Comptroller supported expansion of the NBS Interim Computer to a full-scale machine. The result was the NBS-built Standards Eastern Automatic Computer (SEAC) which went into operation in June 1950, just 20 months after its inception. SEAC, with more than 100,000 connections and components, was the first general-purpose, stored-program computer running in the United States. SEAC performed for 4,000 hours without a malfunction during its first 9 months of operation; its useful life extended over the next 14 years. NBS's Institute for Numerical Analysis, Los Angeles, also built the Standards Western Automatic Computer (SWAC) which was dedicated in August 1950 and became fully operational in early 1952.

NBS conducted exhaustive acceptance tests and directed the installation of the first UNIVAC computer at the Bureau of the Census in June 1951. Computers for other agencies followed and the computer age was underway with a strong push from the National Bureau of Standards.

The pattern of NBS involvement in the development of computer technology had been set. With the implementation of the first computer systems, NBS played a lead role in designing and developing computer applications. The NBS staff developed SEAC applications for handling a number of classified problems for the military services and the Atomic Energy Commission; computations on electronic circuit design; optical lens calculations; statistical sorting and tabulating studies for the Social Security Administration and the Bureau of the Census; design of supersonic nozzles; and computing data on the crystallography of cement compounds and on the penetration of x-rays. The SWAC computer was used to handle problems of the West Coast aircraft industry supporting the Navy, and to do work in engineering, physics and mathematics for NBS and other Federal agencies. NBS personnel played key roles in the development of computer programming languages such as ALGOL and COBOL. NBS continues to assist other agencies in developing computer application. For example, during the period 1965–72 NBS provided more than $12 million worth of services to assist some 50 Federal agencies in solving computer applications problems.

There is a great contrast between the computer problems that confronted the Bureau in the late 1940's and early 1950's and the ones that confront it today. The main concerns in the early years were centered on advancing the hardware technology and developing specific applications. Today, with our extremely sophisticated computers as the major technological ingredient of progress, we are no longer preoccupied with hardware and individual computer programs but instead are focusing on the greater problem of how to insure the quality and effectiveness of the services provided by computer systems. We are, indeed, trying to combat a situation in which our ability to produce computer equipment and programs has far outstripped our ability to measure and judge their quality.

Through its congressionally mandated Center for Computer Sciences and Technology, NBS is carrying out a comprehensive program to focus scientific and technical effort on overcoming the effects of long-standing, technically rooted computer problems. These problems are the result of 25 years of a rampant technology that has far outdistanced its supporting scientific base. The program is aimed at computer problems whose pervasiveness and severity put them in the category of national problems and whose cumulative effect is preventing the full exploitation of the computer as a critical national resource. The target problems are the ones that create a computer marketplace that is unfair to both the buyer and the seller; impede the full use of the computer to increase productivity in the economy; limit the application of computers to improve the quality of life through the provision of higher quality services, better management of critical resources and control of the environment; threaten the individual's rights to privacy; and limit the computer's contributions to a strengthened U. S. position in international trade.

The Center for Computer Sciences and Technology is focusing on a class of computer problems that are application-independent, i.e., they confront all computer customers regardless of the particular use to which the computer is being put. These problems, contrasted with the application-dependent problems whose solutions are provided by mission-oriented agencies, exceed the bounds of mission and resources that single industrial organizations can allocate for their solution. The Center, as the Federal scientific and technical focal point for computer technology under Public Law 89-306, is actively pursuing the solution of a wide range of application-independent problems that impede the effective utilization of computer power.

Today's computer world is dominated by the problems of software and the computer technological supporting system, i.e., the essential legal, economic, administrative, ethical and intellectual arrangements through which computer power is made available to customers. Dr. Ruth Davis, Director of the Center for Computer Sciences and Technology, has succinctly summed up the situation by noting that · software and the technological supporting system have become the "Achilles Heel" in our attempts to channel the power of computers to serve our best interests. The urgency of solving the problems of software management

is underscored by the fact that initial software costs invariably equal hardware costs; for the fully operational system software costs run from three to eight times hardware costs.

One of the Center's principal objectives is to introduce quality control into the production of software. The absence of such controls coupled with the lack of effective techniques for measuring performance and judging quality make software one of the most elusive commodities bought and sold today. These factors make the computer marketplace an unstable one that is unfair to both the buyer and the seller; the buyer can't describe in meaningful terms what he wants to buy and the seller is unable to certify or guarantee performance effectiveness of the products he sells.

In addition to providing the technical leadership for the development of software quality control, the Center is giving high priority to the development of techniques for measuring the performance of computer systems, products and services; the development and implementation of software validation services, starting with COBOL and FORTRAN compilers; the formulation of guidelines and criteria for the interchangeability and compatibility of computer hardware and the sharing of computer software and data bases; formulation of software documentation standards and standardized computer programming languages; and the development of effective techniques for controlling accessibility to computer data banks in order to protect the individual's rights to privacy.

Teleprocessing and computer networking are receiving special emphasis in the computer technology program. The Center is conducting research aimed at improving understanding of computer networks as a basis for enchancing the design effectiveness of networks, measuring their performance, and fostering their use for sharing the expensive resources of hardware, software, and data bases while reducing the dissipation of computer skills in redundant and unproductive work. In a related activity, the Center is using its research in computer networking as a base to provide scientific and technical inputs to support the formulation of policies on the telecommunications required to interconnect the customer with the computer.

The minicomputer—the most dramatic advance in computer technology in the last 5 years—is another important aspect of the NBS program. In 1967, there were some 6,000 minicomputers in the United States; the number had grown to more than 25,000 by 1970 and is still growing at a rapid pace. The minicomputer's low cost and versatility are significantly altering the pattern of computer usage. The Center is working to develop guidelines for determining the optimum effective mix of minicomputers and large computers within a system or network, and for coping with the growing problems in the selection and acquisition of minicomputers.

While the Federal computer customer is the first concern of the NBS program under P.L. 89-306, all computer customers are beneficiaries of the Center's work on the application-independent problems of computer technology. In some instances, under the NBS charter to make science and technology available for use by society, the Center participates directly in efforts to exploit the computer to improve business and commerce. An example is the Center's work with the National Retail Merchants Association to apply computer and automatic reading technologies to automated merchandise and credit customer identification in retail industry, an industry which accounts for a large fraction of all the manpower in the services sector of the economy. The Center's role is focused on helping with the development of voluntary industry standards.

SEAC, an NBS-built computer that went into operation in 1950, was the first general-purpose, stored-program computer operating in the United States.

In the years since the SEAC computer, NBS has been on the frontiers of the most spectacular technological advance in man's history. Where once the Bureau was the developer of the hardware technology, it now stands at the forefront of a great effort to learn how to effectively manage computer resources and to fully exploit the potential of that technology for the benefit of man and the welfare of the Nation. If used properly, the computer has almost incalculable potential for service in man's interest; if misused, it has almost equal potential for disbenefit and wastage of resources. NBS is dedicated to insuring that the computer's potential for benefit is realized.

NSRDS NEWS

The NSRDS was established to make critically evaluated data in the physical sciences available to science and technology on a national basis. The NSRDS is administered and coordinated by the NBS Office of Standard Reference Data.

THEORY OF CHARGE EXCHANGE

Theory of Charge Exchange by Robert A. Mapleton is the second NSRDS volume in a planned series of critical reviews on atomic and molecular-collision processes. The volume was published by Wiley-Interscience under the sponsorship of the Atomic and Molecular Processes Information Center, Oak Ridge National Laboratory.[1] The first volume in the series was *Ion Molecule Reactions* by E. W. McDaniel, V. Cermak, A. Dalgarno, E. E. Ferguson, and L. Friedman.[1] These two volumes are critical reviews under the general editorship of C. F. Barnett, Director of the Atomic and Molecular Processes Information Center. This Center has been supported jointly by the NBS Office of Standard Reference Data and the U.S. Atomic Energy Commission.

Theory of Charge Exchange presents an explanation of theoretical and experimental features of electron capture. Specifically, the book deals with the quantum mechanical and classical mechanical approximations commonly used to calculate cross sections for electron capture from atoms by positively charged nuclei. Chapter 6 presents comparisons of theoretical and experimental cross sections up to 10^5 keV. Other features in the book are detailed explanations of the impact parameter method and the specialized language used by researchers in the field. Twenty-six figures comparing measured and calculated cross sections show the reader where improvements in approximation methods are needed. An appendix describes the use of fractional parentage coefficients in calculations of electron capture from many-electron atoms.

MÖSSBAUER EFFECT DATA INDEX

Mössbauer Effect Data Index (MEDI), edited by John G. Stevens and Virginia E. Stevens, is a continuation of the *Mössbauer Effect Data Index* 1958-65. This latest volume, covering the literature through 1970, contains over 1,000 systematically arranged references and data on more than 2,400 samples. It also contains handy summaries of the nuclear and Mössbauer properties of various isotopes and a partial listing of 1971 references. Included are 12 appendices: Appendix A covers the abbreviations used in the 1970 *Mössbauer Effect Data Index;* Appendix B is a summary sheet of information for each isotope; Appendix C diagrams the Mössbauer periodic table; Appendix D is a condensed table of Mössbauer transition properties; Appendix E covers the nuclear radii data reported in the 1970 Mössbauer literature; Appendix F covers nuclear moment results reported in the 1970 Mössbauer literature; information for Fe^{57} and Sn^{119} Mössbauer spectroscopy is available in Appendices G and H; Appendix I is a paper entitled "An Introduction to Electric Quadrupole Interactions in Mössbauer Spectroscopy," by B. D. Dunlap; Appendix J lists "Nomenclature and Conventions for Reporting Mössbauer Spectroscopic Data," by J. J. Zuckermann; Appendix K provides English translations of Russian articles available through MEDI; and Appendix L is a chart diagraming the growth of Mössbauer literature and data.

The *Mössbauer Effect Data Index*, which was supported in part by the NBS Office of Standard Reference Data, may be purchased from the Plenum Publishing Corp., 227 West 17th Street, New York, N.Y. 10011 at $29.50 for institutions and $19.50 for individuals.

STRUCTURE DATA ON ELEMENTS AND INTERMETALLIC PHASES

Volume 6 of the new series in the Landolt-Börnstein *Numerical Data and Functional Relationships in Science and Technology*, Group III: *Crystal and Solid State Physics*,

entitled *Structure Data of Elements and Intermetallic Phases*, by P. Eckerlin and H. Kandler with assistance by A. Stegherr, has recently been published.[2] This volume continues the compilation of structural data on crystals started with volume 5 in the Group III series. The volume contains a compilation of structure data and important information on the structure determination for elements and intermetallic phases contained in the literature up to the end of 1967. Compiled are data on the space groups, the lattice constants with their dependence on temperature and pressure, as well as other information. While a complete presentation of all atomic parameters was not possible within the limits of this volume, references are given when the cited original paper contains a complete structure analysis. The substances are arranged alphabetically within each chapter. A list of mineral and common names is given at the end of the volume.

SFCSI LIST OF TRANSLATIONS

The National Science Foundation has announced and published a list of translations in process during 1971 under its Special Foreign Currency Science Information program (SFCSI).

As translations are completed they are announced in the *U.S. Government Reports Announcements* (GRA) available from the National Technical Information Service. Most of the items are priced at $3 for paper copy and 95 cents for microfiche and are available from NTIS although some are available from the sponsoring agency only. Translations are arranged under six major headings: physics, mathematical sciences, environmental sciences, engineering, life sciences, and social sciences with a further breakdown according to sponsoring agency. The SFCSI list may be obtained without cost from the National Technical Information Service, Sills Building, Springfield, Va. 22151.

CATCH TABLES

The CATCH (*C*omputer *A*nalysis of *T*hermo-*CH*emical data) Tables is a project which provides a new service for thermochemists and thermodynamicists. The tables consisting of enthalpies of formation of chemical species are to be computer-generated for ease of updating and reliability of printing. Critically evaluated data on heats of reactions will be provided by a group of experts. The computer will then generate that set of standard enthalpies of formation that is internally self-consistent and in closest agreement with the input data as determined by suitable least-squares techniques.

The CATCH Tables have been developed by Dr. J. B. Pedley, School of Molecular Sciences, University of Sussex, Brighton, England. The cooperating thermochemists who will provide the critically evaluated data and the areas they will cover are the following:

Halogen Compounds

Dr. J. D. Cox (NPL)

Boron Compounds

Dr. A. Finch, Dr. P. J. Gardner, and Mr. N. Hill (Royal Holloway College)

Phosphorus Compounds

Dr. A. J. Head (NPL), Compounds of Aluminium, Gallium, and Thallium
Dr. R. J. Irving (University of Surrey)

Compounds of Germanium, Tin, and Lead

Dr. P. G. Laye and Dr. A. S. Carson (University of Leeds)
Dr. W. V. Steele (University of Sterling)

Compounds of Transition Metals (especially complex ions in solution)

Dr. C. T. Mortimer (University of Keele)

Silicon Compounds

Dr. J. B. Pedley (University of Sussex)

Nitrogen Compounds

Dr. G. Pilcher (University of Manchester)

Compounds of Molybdenum, Chromium, Tungsten, and Vanadium

Dr. H. A. Skinner (University of Manchester)

Organic Free Radicals

Dr. R. A. Jackson (University of Sussex)

Gaseous Ions from Lattice Energy Calculations

Dr. H. D. B. Jenkins (University of Warwick)
Prof. T. C. Waddington (University of Durham)

Sulphur Compounds

Prof. S. Stinner and Dr. Margaret Mänson (University of Lund)

Dissociation Energies of Small Molecules

Dr. J. A. Kerr (University of Birmingham)

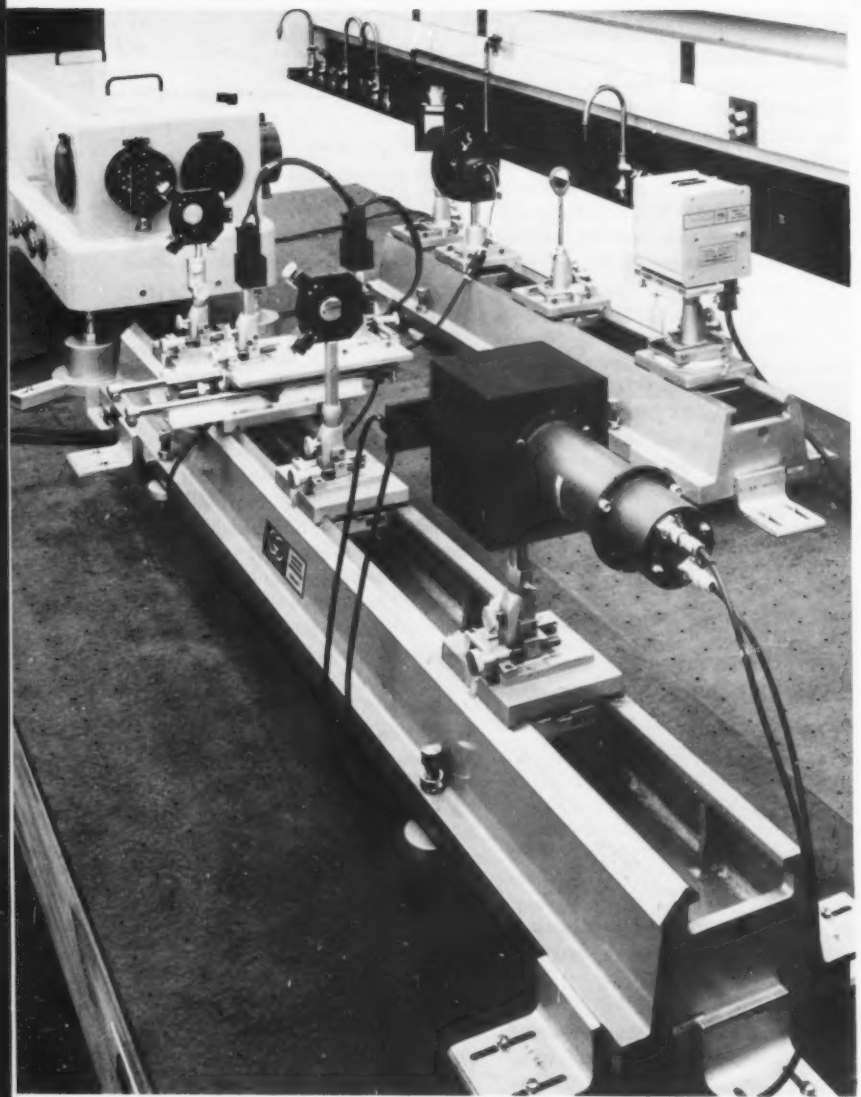
At the present time a set of three tables and a bibliography for nitrogen compounds have been produced. The first table lists the standard enthalpies of formation of 466 nitrogen compounds (including various dilutions considered as distinguishable compounds). Also included are an estimate of the reliability and the number of the reaction or reactions used in determining the enthalpy (the numbers refer to order in another table). The table of reactions shows the chemical equation of the reaction, the standard enthalpy of the reaction, a measure of the reliability, and the reference to the experimental measurements used. Also included is the difference between the experimental value and the enthalpy of reaction as determined from the standard enthalpies of formation. A third table lists enthalpies of formation of compounds which do not contain nitrogen but are needed to complete the calculation of enthalpies of formation from enthalpies of reaction.

The calculation of the enthalpies of formation proceeded as follows: If a reaction contained a compound which occurred only once in the entire section then the enthalpy of formation of that compound was uniquely defined by that reaction.

continued on page 173

HIGH-ACCURACY SPECTROPHOTOME

APPLICATION IN THE DEVELOPMENT OF CALIBRATION STANDARDS



General view of the high-accuracy spectrophotometer. Upper right: optical bench carrying the radiation source, followed by a quartz lens, a circular quartz neutral wedge, and a flat mirror. Upper left: the 1-meter Czerny-Turner grating monochromator. Front: optical bench carrying a quartz lens, the single-sample carriage, a second quartz lens, and integrating sphere with the photomultiplier housing.

A spectrophotometer that measures transmittance data to 0.1 percent accuracy has been constructed at NBS.

Dr. R. Mavrodineanu of the Analytical Chemistry Division designed the research spectrophotometer after consultation with F. J. J. Clarke of the National Physical Laboratory, England, and with scientists in the NBS Institute for Basic Standards.[1,2] This instrument was utilized to develop optically neutral glass and liquid filters that have been certified as Standard Reference Materials (SRM 930 and SRM 931).[3] Use of these filters to check the photometric scale of spectrophotometers in clinical, analytical, and research laboratories will provide a more reliable basis for interlaboratory comparisons of data.

This spectrophotometer measures radiant energy of the visible and ultraviolet regions of the spectrum with well-established photometric accuracy. It is calibrated by independent physical means to assure a minimum of systematic errors. Wavelength accuracy and spectral bandpass are compatible with the photometric accuracy.

The high-accuracy spectrophotometer is a single-beam instrument containing a constant radiation source, a monochromator, a sample carriage, a system to check the linearity of the photometric data, an integrating sphere-photomultiplier assembly, and a

OMETRY

DS

Dr. Mavrodineanu adjusts the optical lens in front of the multiple-sample carriage. The 15 position switches (7 sample positions and 8 blank positions) are visible along with the two quartz lenses. The exit slit of the monochromator is at the left. This platform is operated automatically through a computer interfaced with the instrument.

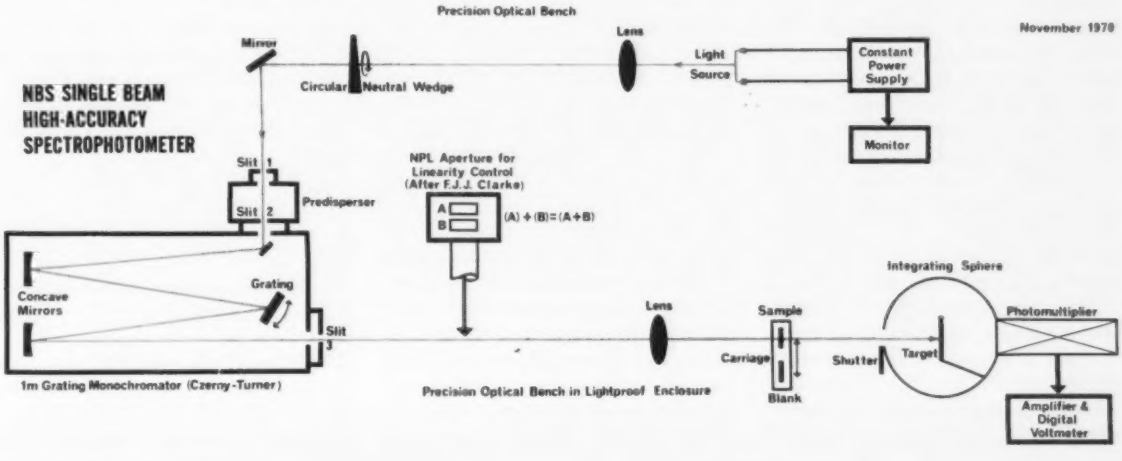
data presentation system. A neutral wedge, placed after the radiation source, is used to select the various radiation intensities required for measurements.

An incandescent tungsten ribbon-filament lamp serves as the radiation source for measurements in the visible spectrum. For measurements in the ultraviolet region, a single coil tungsten-bromine incandescent lamp is used as the radiation source. A demagnified image of the ribbon filament is projected onto the entrance slit of the predisperser by a fused quartz (nonfluorescent SiO_2) lens. Placed between the radiation source and the predisperser is a circular neutral wedge, linear in density, that provides light attenuation of 100 to 1. The wedge is motor driven for selection of proper radiation levels.

The monochromator is a 1-meter Czerny-Turner grating instrument provided with a predispersing attachment to reduce the stray light. A wavelength counter permits readings to 1 Å; the scanning speed can be varied from 0.5 to 2000 Å/min. The optical components, placed on precision lathe-bed optical benches, are equipped with carriers adjustable in the x, y, and z axes.

Two sample-carrying systems can be used in this spectrophotometer. One system measures a sample and its blank, while the other system permits sequential measurements of seven samples and eight reference positions. The multiple-sample unit can be operated manually or automatically through a computer interfaced with the instrument. Both sample carriers are designed to accept conventional solid or liquid filter holders. These holders are provided with a thermostated jacket.

Schematic description of the high-accuracy spectrophotometer.



Radiations are emitted from the exit slit of the monochromator, passed through the aperture or filter, and received on the target of the integrating sphere. Through this arrangement, the sensitive surface of the photodetector receives the radiations originating from the exit slit of the monochromator only after these radiations have undergone at least two diffuse reflections. Optical components located after the exit slit of the monochromator, including the photomultiplier tube, are enclosed in a light-tight box.

Since the high-accuracy spectrophotometer is single-beamed, accurate photometric data are obtained when there is a linear relation between the radiation flux measured and the corresponding response of the photodetector. A light addition principle, using two apertures with one source of radiation, was used to measure the linearity of the photodetector. The two-aperture unit consists of a metal plate containing two rectangular windows, A and B, located one above the other. Both apertures can be closed by a light-tight shutter, operated pneumatically by remote control. The aperture plate is placed in the optical path after the exit slit of the monochromator and within the optical solid angle of the instrument. The linearity is checked by measuring the photocurrent produced when each aperture is opened individually. The value of A + B is compared to the values obtained with both apertures (A + B) open. In a linear system these two values will be identical; if linearity is not demonstrated, the nonlinearity is proportional to the difference between A + B and (A + B). This difference is used to correct the transmittance values measured on the solid or liquid filters.

Data output from the digital voltmeter (DVM), corresponding to the current generated at the photomultiplier tube by the radiations passing through the system, can be obtained by visual means or computer operation. Both methods have been used with good results. In the visual mode, the operator examines the digital voltmeter display and takes a mental average of the data. The display rate is adjusted to one reading per second.

When measurements are taken by computer, signals from the DVM are recorded at a faster rate, for example, 10 to 20 data per second. The computer is programmed to take a predetermined number of individual DVM readings, print the arithmetic average, followed by the standard deviation, relative standard deviation, percent transmittance, and sample position. At the conclusion of each measurement, the computer initiates a signal that rotates the carriage to the next position.

A set of solid filters was used in a comparative test to determine the reproducibility of transmittance measurements between two laboratories. This set was made up of three neutral glass filters having nominal percent transmittances of 10, 20, and 30. The transmittance measurements were performed on the filters at the National Physical Laboratory, England, by Dr. Clarke on the high-accuracy spectrophotometer available there, and at NBS on the instrument described here. The measurements at NBS were carried out before and after the measurements at NPL. Results obtained indicate that an average percent difference of 0.19 of the percent transmittance values was determined between the measurements made at NPL and NBS.

Using this high-accuracy spectrophotometer, two types of filters were developed as Standard Reference Materials. Glass Filters, issued as SRM 930 and certified by R. Mavrodineanu and J. R. Baldwin, consist of three neutral glass filters having transmittances of approximately 10, 20, and 30 percent. Each filter is individually calibrated and certified for absorbance and transmittance over a spectral wavelength range from 440 to 635 nm. SRM 931, Liquid Filters, developed by R. W. Burke and E. R. Deardorff, consists of empirical mixtures of cobalt, nickel, and nitrate ions in 0.01N perchloric acid. Each SRM unit is composed of three sets of three liquid filters and a blank that have absorbances certified at 25 °C and at wavelengths 302, 395, 512, and 678 nm. These filters are intended to check the accuracy of the photometric scale of spectrophotometers, and to provide a means for interlaboratory comparisons of data. It is probable that in the field of clinical chemistry large amounts of data are being collected on precision instruments whose accuracy is unknown. To make these data more meaningful and universally applicable, the biases between instruments must be eliminated or at least determined. A major purpose of these filters is to assure that systematic errors due to a particular characteristic or condition of an instrument can be recognized.

The SRM's should be valuable in checking the calibration of instruments used to obtain accurate physico-chemical constants such as molar absorptivity and equilibrium constants. For example, current interest in molar absorptivity values, as an index of the purity of biological clinical materials, requires greater accuracy of measurement. Also, the accuracy in the determination of equilibrium constants of chemical reactions in solutions is dependent on true values of their molar absorptivities.

[1] Mavrodineanu, R., Solid Materials to Check the Photometric Scale of Spectrophotometers, Nat. Bur. Stand. (U.S.), Tech. Note 544, O. Menis and J. I. Shultz, Eds., pp. 6-17 (Sept. 1970). Available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, SD Catalog No. C13.46:544. Price $1.25.

[2] Mavrodineanu, R., Spectrophotometry, Instrument Development, Nat. Bur. Stand. (U.S.), Tech. Note 584, O. Menis and J. I. Shultz, Eds., pp. 9-21 (June 1971). Available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, SD Catalog No. C13.46:584. Price $1.50.

[3] Available from the Office of Standard Reference Materials, National Bureau of Standards, Washington, D.C. 20234. SRM 930 is priced at $300 per set of three filters; SRM 931 costs $65 for a set of 12 vials.

Rotary-vane attenuator is adjusted while operator views readout through the optical viewer. The device features 10 times better resolution and is more accurate than similar attenuators.

HIGH-PRECISION ROTARY-VANE ATTENUATOR

A precision rotary-vane attenuator, developed at the Bureau's Boulder, Colo., Laboratories, affords 10 times better resolution than similar rotary-vane attenuators.[1] In making microwave attenuation measurements at x-band frequencies, the device follows the cosine-squared law so closely that deviations are barely detectable at levels below 20-dB attenuation.

High performance of the reference-standard quality instrument derives from the design as well as the special care exercised during fabrication. Employing an engraved-glass scale calibrated in degrees and fixed directly to the rotor, the instrument is read, with a built-in microscope, at two points 180 deg apart to minimize readout errors. This optical readout feature eliminates gear-drive error and backlash, and reduces errors attributable to unavoidable eccentricities in rotating parts. By surrounding the rotating joints with microwave absorbing materials, external leakage errors are reduced. Extremely careful alignment of the stationary vanes and the extra-heavy construction of the housing preserves the precision achieved by the other measures. A bellows connection between the drive and rotor eliminates distortion within the instrument attributable to the small forces required to set the dial.

With partial support from the Calibration Coordination Group of the Department of Defense, the development of the device evolved from the efforts of W. E. Little, W. Larson, and B. J. Kinder of the NBS Electromagnetics Division. These attenuators are useful in evaluating r-f measurements systems, space tracking and communication systems, measuring r-f properties of materials, and as laboratory standards. Because the instrument allows a more accurate determination of r-f output power, design "fudge factors" may be reduced thus saving valuable equipment and operating costs.

In the range from zero to 20 dB, the new attenuator is accurate to within 0.1 percent, and for measurements up to 0.1 dB, the accuracy is 0.001 dB or better and the resolution is of the order of a few microbels. Thus, in this range the device serves as a primary reference standard, and above 20 dB as an excellent working standard, provided it is first calibrated to allow for frequency dependence. An improved design further reduced frequency dependence and leakages in the vane-resistance.

The attenuator should have wide application when it is not feasible to evaluate systems section by section, as in some of the dual-channel r-f attenuation-measuring systems. In the latter, the standard piston attenuators cannot be independently evaluated. Rotary-vane attenuators are also useful in the same fashion that we presently employ 30-MHz waveguide-below-cutoff attenuators and the straight r-f substitution technique. Up- and down-converters can bring the measurement into the range of the attenuator. Another useful application is the measurement of very small attenuation values.

No other techniques are known to exist for achieving a change in attenuation of a few hundredths of a decibel with the accuracy and resolution offered by the ultra-precision rotary-vane attenuator.

[1] Little, W. E., Larson, W., and Kinder, B. J., Rotary-vane attenuator with an optical readout, J. Res. Nat. Bur. Stand. (U.S.), **75C**, No. 1 (Jan.-Mar. 1971).

LASER BEAM TESTS PRESSURE TRANSDUCERS

THERMAL TRANSIENTS TRY PERFORMANCE

A laser beam has been used as a heat source in determining the response of pressure transducers to abrupt temperature changes. Paul Lederer and John Hilten, of the Bureau's Instrumentation Applications Section, developed the test method[1] for the Atomic Energy Commission. Because it is effective, cheap, and quick, the test makes it possible to determine the response of pressure transducers to rapid temperature changes before they are put in service.

Pressure transducers are widely used to measure pressures of gases and liquids in atomic energy installations, the aerospace program, and in industrial process control. Manufacturers of pressure transducers specify the accuracy of their instruments within a given range of steady-state temperatures, but not during abrupt thermal changes. As the research program of the Atomic Energy Commission requires pressure measurements within rapidly changing thermal environments, the AEC sponsored research at the Bureau on determining if pressure transducers meet performance requirements during exposure to temperature transients.

In 1965 the Bureau had studied changes in the zero-pressure output of transducers subjected to sudden heat.[2] Short-term errors were substantial—reaching 100 percent of full-scale indication in some cases—and unpredictable. The experimental setup used did not allow pressure to be applied to the transducer diaphragm along with the heat, so the extent of impairment of the total dynamic response by thermal transients has been unknown until the present.

TESTING APPARATUS

The pressure transducer to be tested was clamped in a hole in a test fixture with its diaphragm flush with the inside wall and facing the laser beam through a glass window. The test fixture was mounted on the rails of an optical bench, as was a continuous-wave, yttrium-aluminum-garnet laser emitting a thin beam of infrared radiation (1.06 μm) when energized by light from two krypton arc lamps. The laser system was used at optical power output levels delivering up to 12.5 watts at the transducer diaphragm, producing a maximum observed diaphragm temperature of 88 °C. Even instantaneous spot temperatures could not have exceeded the operating limits of the transducers tested.

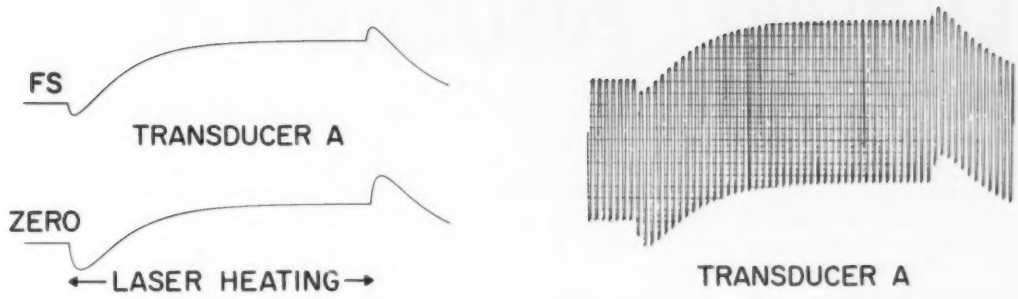
A thermal transient was generated when a mechanical shutter between the laser and the transducer was raised manually to permit the laser beam to reach the transducer diaphragm. Tests were run at several optical power levels by varying the power input to the laser.

The transducers were pressurized under test by regulating the laboratory compressed-air supply at the top of the range for the transducer and switching the pressure in the test fixture from the ambient to pressure and back again. This could be done manually and also automatically, the fixture being alternately pressurized and vented to the atmosphere by a solenoid-operated valve, energized by switches actuated by a motor-driven cam.

The output of the transducer under test was recorded by an x-y recorder; the plot was started before the test variation and ended after recovery of the instrument's output.

TRANSDUCER TESTING

Four flush-diaphragm pressure transducers that were on hand were used to test this method of measuring performance during thermal transients. Three of the instruments were different models of unbonded wire strain-gage transducers and one was a semiconductor type with its strain gage diffused into a silicon diaphragm. Each transducer was



Typical plot of pressure transducer output shows displacement of zero- and full-scale indications due to thermal gradients. A similar pattern is evident superimposed on squarewave cycling between zero pressure and the specified maximum for each transducer.

run through three tests: a zero-and-full-scale test, a pressure cycling test, and an extended-time pressure cycling test.

In the zero-and-full-scale test the recorder was turned on, the shutter opened after 8 seconds for a 50-second exposure, and the transducer zero output traced during this sequence. Then the pen was returned to the starting position, the transducer was pressurized to the maximum level, and the run was repeated as before. The graph contains two parallel plots showing the changes, caused by the laser irradiation, of the output signals at zero and the maximum allowable pressures.

The transducer was then subjected to pressure cycling, in which it was pressurized at zero and full pressure alternately at a rate of 50 full cycles per minute. The irradiation pattern was the same as used for the previous test, with pressure cycling continuing to the end of the plot.

The extended pressure cycling test was similar, except that radiation was maintained for much longer and the test was run for 320 seconds.

FINDINGS

The recorded plots showed that for the unbonded strain-gage transducers the diaphragm pressure indication fell as soon as the laser beam impinged on it, then reversed direction, and stabilized within 20 seconds at a level considerably above the original zero. This was interpreted as being due to outward expansion of the pre-loaded diaphragm, when heated by the radiation, and the subsequent catching-up of the positive-going response as temperatures within the transducer equalized and became stabilized. The mirror image of this displacement occurred when the shutter was closed, indicating that the processes involved were then reversed. These plots could be seen, also, in the outlines of the pressure cycling test. The semiconductor-type transducer showed qualitatively similar characteristics, although the laser heating resulted in far greater changes in the transducer output.

The output of two transducer models jumped 10-15 percent of full scale on application of the radiation, another about 50 percent, and others tested later still more. Most of the displacements exceeded considerably the limits specified by the manufacturer for steady-state conditions. For this reason those who plan to use pressure transducers in environments containing thermal transients are advised to test the actual transducer specimens being considered, using a method simulating the application conditions.

The transducers were also tested when mounted on a heat-insulating plug, instead of on highly conductive brass, to determine if the temperature-related changes in output depend on conduction of heat from the transducer. The plots obtained using the insulating mounting were essentially similar to the others.

Findings related to the test itself are that either the zero-and-full-scale or the pressure cycling tests are useful for testing transducer performance; that the pressure cycling test may be preferred because it is quicker than the other; and that a test time of a minute is probably sufficient to establish the response of the transducers tested. Supplementary testing at less than the full range of the transducer has been effective and tests using pressures of 1/4 of the instrument's maximum range appear to be valid.

[1] Lederer, P. S., and Hilten, J. S., A Laser Technique for Investigating the Effects of Thermal Transients on Pressure Transducer Performance Characteristics, Nat. Bur. Stand. (U.S.), Tech. Note 723, available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 as SD Catalog No. C13.46:723.

[2] Pressure transducer response/Affected by thermal gradients, Nat. Bur. Stand. (U.S.), Tech. News Bull. **54**, No. 4, 64-65 (1966).

CONFERENCE & PUBLICATION *Briefs*

SIXTH MATERIALS RESEARCH SYMPOSIUM ANNOUNCED

"Standard Reference Materials and Meaningful Measurements" will be the subject of the Sixth Materials Research Symposium. Sponsored by the Bureau's Institute for Materials Research, the Symposium will be held October 29—November 2, 1973, at the National Bureau of Standards, Gaithersburg, Md.

Topics to be considered include: international SRM aspects and possibilities for cooperation among nations; new needs for SRM's in industry and technology; the role of SRM's in national concern areas of health and environment; and SRM's as related to working standards and the quality control process. The Symposium will consist of three types of presentations: General sessions will be used to cover topics of widespread interest; concurrent sessions will be held on more specialized topics; panel discussions and question and answer sessions will be conducted on some subjects. Invited and contributed papers will be presented.

Standard Reference Materials are well characterized materials certified for chemical composition or for a particular physical or chemical property. They are disseminated by NBS to calibrate and evaluate measuring instruments, methods, and systems or to produce scientific data that can readily be referred to a common base. The importance and future of their role in the measurement field is the main theme of the Symposium.

To receive further details of this Symposium as they become available, write to:

Office of Standard Reference Materials
SRM Symposium
National Bureau of Standards
Washington, D.C. 20234

CYCLIC DESIGNS

Cyclic Designs, a a new collection of experimental designs by J. A. John, F. W. Wolock, and H. A. David, reminds us that the statistical design of experiments had its first crude beginnings in the weighing and trend elimination designs of early physicists and chemists. Conspicuous development of the field did not occur, of course, until the second quarter of this century, and then it was in the context of the agricultural and biological sciences. More recently the physical sciences have adapted to their own needs many of the experimental arrangements that have proven so valuable to these other fields. The physical sciences have also generated many new classes of designs which, by their concern for efficiency and objectivity in experimentation, are helping to set more exacting standards for scientific conclusions. This volume presents an enumeration of designs that have been used in many fields of investigation and have incidentally been particularly useful in the calibration work of the National Bureau of Standards.

Specifically, the publication is concerned with incomplete block designs based on cyclic development of an initial block or blocks. The authors note that the flexibility, ease in conduct of the experiment, and natural grouping for elimination of heterogeneity make these designs worthy of attention in their own right, even if their analysis does not have the ease of computation of the more common completely balanced or partially balanced incomplete block designs with two associate classes. The tabulation of designs is preceded by a discussion of methods for their construction and analysis and a numerical example is given. An appendix describes the application of a cyclical design to voltage calibration at NBS.

The 79-page *Cyclic Designs* is available for 75 cents from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, or local U.S. Department of Commerce Field Offices as SD Catalog No. C13.32:62; microfiche copy is available for 95 cents from the National Technical Information Service, Springfield, Va. 22151, as NBS AMS-62.

THE INTERNATIONAL SYSTEM OF UNITS

The International System of Units (SI) edited by Chester H. Page and Paul Vigoureux, is the second edi-

tion of an official description of the metric system in its present-day form, the first edition having been sold out in less than a year. The new edition is brought up to date with the decisions of the 14th General Conference of Weights and Measures (CGPM) and takes account of recommendations proposed by the Consultative Committee for Units. In the Foreword, J. Terrien, Director of the International Bureau of Weights and Measures (BIPM), expresses the hope that "this approved translation will promote knowledge and understanding of the International System of Units, encourage its use in all realms of science, industry, and commerce, and secure uniformity of nomenclature throughout the English-speaking world."

Official definitions and symbols are given of the SI base units: for length (metre), mass (kilogram), time (second), electrical current (ampere), thermodynamic temperature (kelvin), luminous intensity (candela), and amount of substance (mole); a sampling of derived units (units expressible in terms of the SI base units), some with and some without special names; the units of plane and solid angle (radian, steradian), which are not classified as either "base" or "derived"; and the prefixes used to express decimal multiples and sub-multiples of units (e.g., "mega" and "nano" correspond respectively to 10^6 and 10^{-9}). There are also tables of various groups of non-SI units, some (e.g., hour, litre) considered permanent auxiliaries to the SI units, others (e.g., nautical mile, bar) to be retained for a "limited time," and still others (e.g., micron, kilogram-force) whose use is "generally deprecated."

Appendix I reproduces in chronological order the recommendations, resolutions, etc. promulgated since 1889 by the General Conference of Weights and Measures and the International Committee of Weights and Measures on units of measurement and the International System of Units. Appendix II outlines the methods by which metrological laboratories can build standards embodying important SI Units. Appendix III, added in the second edition, describes the functions of the General Conference (CGPM), International Committee (CIPM), and International Bureau of Weights and Measures (BIPM).

Order *The International System of Units* from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, or local U.S. Department of Commerce Field Offices as SD Catalog No. C13.10:330/2; price 30 cents.

NSRDS NEWS *continued*

For those compounds which occurred in more than one reaction, the computer produced a hard core of equations which formed an overdetermined set for the calculation of the enthalpies of formation. This set was analyzed using a least-square procedure with the reciprocal of the uncertainty used as a weight. The residuals were also determined and serve to measure the compatibility of a specific reaction with the others. The use of the computer in this way allows rapid and systematic introduction of additional or improved data as they become available.

Data on inorganic halogen compounds and inorganic phosphorus compounds have also been processed and are ready for printing, and others are in process.

The CATCH Tables have been priced to recover costs of postal, secretarial, computing, and printing services. Inquiries or orders should be directed to Dr. J. B. Pedley or The Scientific Accountant, Science Office, University of Sussex, Brighton, BN1 9QH, Sussex, England.

ALUMINUM WIRE TABLES

NBS Handbook 109, *Aluminum Wire Tables*, edited by D. Peterson and J. L. Thomas[3] (SD Catalog No. C13.11:109, 65 cents) was issued in February 1972. Paralleling the growth of the electrical distribution system in this country is an ever-increasing use of aluminum transmission lines. To meet the resulting need by the engineering profession for reliable design information, NBS and the Aluminum Association have prepared the aluminum wire tables that make up this handbook. Data are presented on the conductivities and resistivities of both solid and stranded wires of various sizes and composition, together with a variety of other data of interest to the designer of electrical equipment and installations. Values are expressed in both U.S. Customary and International System (SI) units. The wire sizes dealt with are based on and restricted to those manufactured and typically used in the United States. American Wire Gage sizes are used for the smaller range of conductors from 56 gage through 4/0. Larger conductors are sized on the basis of circular-mil area. The alloy compositions included on these tables are EC-0 (annealed), EC-H19, 5005-H19, and 6201-T81; values are given for temperatures in the range from 0 to 100 °C.

This publication is a companion to NBS Handbook 100, *Copper Wire Tables*[3] (SD Catalog No. C13.11:100, 50 cents) issued February 1966.

[1] Available from Wiley-Interscience, 605 Third Avenue, New York, N.Y. 10016. The price for each is $19.95.

[2] Available from Springer-Verlag, 175 Fifth Avenue, New York, N.Y. 10010 for the price of $179.10.

[3] Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for the price indicated.

INTERNATIONALIZING MAGNETIC TAPE STANDARDS

Work by the Bureau is leading the way to international standards of measurement for computer tape.

The Bureau's Center for Computer Sciences and Technology (CCST) has calibrated tapes and heads sent from other countries and has embarked on a program for the international exchange of magnetic computer tapes for comparison of calibrations. Such cooperation enables tapes produced in any country to be run on the computers of any other.

Almost any audio tape will work in home tape recorders because equipment requirements are not severe, users may be uncritical, and most manufacturers try to match their products to prevailing levels of performance. Magnetic tape for computers and recording instrumentation, on the other hand, must meet stringent requirements to work well in the equipment that it is intended for. Ideally, all computer and tape manufacturers the world over should follow the same engineering standards and standards of measurement, but progress toward this goal requires successive agreements to make use of common standards. The International Organization for Standardization, which is working toward an international standard for magnetic computer tape, requested the National Bureau of Standards to disseminate its standard magnetic reference tapes and the details of its measurement system for use internationally.

In fulfilling its responsibilities to users of computer tape in Government, the NBS Computer Center conducts a continuing program of research on characterizing magnetic tape. The expertise developed at the Center has been employed by the GSA Magnetic Surfaces Laboratory to develop and supply systems for measuring the critical characteristics of computer and instrumentation tape. The existence of the NBS system and the use of the GSA specifications in Government purchasing encouraged the use of the same system and standards by the U.S. tape and computer manufacturers and users.

A program is underway to certify secondary reference digital tape cassettes (foreground). The apparatus on which Amory Ericson is preparing to calibrate an International Standard Magnetic Tape (NBS-SRM 3200) will also be used to calibrate cassettes.

The NBS work on magnetic reference tapes resulted in 1967 in an invitation for an NBS representative to visit the Physikalische Technische Bundesanstahlt (the PTB), which had been assigned the responsibility for making computer reference tapes available in West Germany.

In 1970, members of the Deutscher Normenausschuss made two visits to NBS to observe its work and to discuss the magnetic tape signal amplitude measurement system just developed at NBS.[1] Subsequently the PTB decided to duplicate the NBS amplitude measurement system for its own use and visited NBS again, in 1971, to discuss details of the system and to take part in the calibration of several magnetic recording heads to be used in the German national system.

NBS has been performing correlation studies with England's National Physical Laboratory (NPL), which in 1970 was considering undertaking a study of measurement techniques for computer recording heads and tape. NBS and NPL agreed to an exchange of reference measurements and in April 1971 concluded plans for the mutual exchange of unrecorded reference tapes. Several tapes were received from NPL in August 1971 and were returned shortly thereafter with charts and graphs made on the NBS measurement system. NBS has submitted some of its reference tapes for characterization on the NPL system.

In April 1970 a representative of the Canadian Department of Supply and Services visited the CCST's magnetic tape laboratories. This Department had purchased an NBS SRM 3200 Reference Tape and was evaluating the feasibility of establishing a facility to certify and clean magnetic tape in Canada.

The NBS Computer Center was visited by two French groups, one in 1970 from a magnetic tape manufacturer and the other in 1971 from a Government installation. The former brought samples of his tape, which were evaluated on the NBS measurement system; the saturation curves produced were given to the manufacturer for comparison with those obtained on his own equipment. The second visiting group was from France's Centre National d'Etudes des Télécommunications, with whom the NBS measurement system was discussed. An NBS representative also visited these groups to discuss common problems.

In November 1971, NBS was visited by a representative of the Japanese Electronic Industries Development Association's committee for the standardization of digital tape cassettes. He brought samples of cassettes and bulk tape that are now being used as interim standards in Japan, asking that NBS consider these in establishing a primary magnetic tape cassette standard for the United States. NBS has made initial measurements on these cassettes.

Such cooperation with other countries will expedite the formation of international standards for magnetic tape and will create an atmosphere conducive to their acceptance. At the very least, each example of cooperation increases efficiency in procuring computer tape and in exchanging data recorded on the systems of various countries.

[1] Geller, S. B., Calibration of NBS Secondary Standard Magnetic Tape (Computer Amplitude Reference) SRM 3200 Using the Reference Tape Amplitude Measurement "Process A" Model II, Nat. Bur. Stand. (U.S.), Spec. Pub. 260-29, 57 pp. (June 1971), available as SD Catalog No. C13.10:260-29 from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 at a cost of 60 cents.

PUBLICATIONS of the National Bureau of Standards*

PERIODICALS

Technical News Bulletin. Annual subscription: Domestic, $3; foreign, $4. Single copy price, 30 cents. Available on a 1-, 2-, or 3-year subscription basis. SD Catalog No. C13.13:56.

Journal of Research of the National Bureau of Standards

Section A. Physics and Chemistry. Issued six times a year. Annual subscription: Domestic, $9.50; foreign, $11.75. Single copy price varies. SD Catalog No. C13.22/sec.A:74.

Section B. Mathematical Sciences. Issued quarterly. Annual subscription: Domestic, $5; foreign, $6.25. Single copy, $1.25. SD Catalog No. C13.22/sec.B:74.

Section C. Engineering and Instrumentation. Issued quarterly. Annual subscription: Domestic, $5; foreign, $6.25. Single copy, $1.25. SD Catalog No. C13.22/sec.C:74.

NBS BIBLIOGRAPHIC SUBSCRIPTION SERVICES

Cryogenic Data Center Current Awareness Service (Publications and Reports of Interest in Cryogenics). A literature survey issued weekly. Annual subscription: Domestic, $15; foreign, $20.

Liquefied Natural Gas. A literature survey issued quarterly. Annual subscription: $15.

Superconducting Devices and Materials. A literature survey issued quarterly. Annual subscription: $15.

Send subscription orders and remittances to the Cryogenic Data Center, Room 2022, Cryogenics Building, National Bureau of Standards, Boulder, Colo. 80302.

Electromagnetic Metrology Current Awareness Service (Abstracts of Selected Articles on Measurement Techniques and Standards of Electromagnetic Quantities from D-C to Millimeter-Wave Frequencies). Issued monthly. Annual subscription: $100 (special rates for multi-subscriptions). Send subscription order and remittance to the Electromagnetic Metrology Information Center, Electromagnetics Division, National Bureau of Standards, Boulder, Colo. 80302.

CURRENT ISSUES OF THE JOURNAL OF RESEARCH

J. Res. Nat. Bur. Stand. (U.S.), **76A** *(Phys. & Chem.)* (July-August 1972), SD Catalog No. C13.22/sec.A:76/4.

Fanconi, B. M., Lattice vibrations of antiparallel chain sheet structures.

Fussell, W. B., Normal emissivity of an isothermal, diffusely reflecting cylindrical cavity (with top) as a function of inside radius.

Haller, W. and Simmons, J. H., Anatomy and thermal history of laser self-focusing damage tracks in glass.

Hamer, W. J., Skapars, A. and Field, B. F., The emf-temperature coefficient of "acid" standard cells of the saturated cadmium sulfate type from 15 to 40 °C.

Rebbert, R. E. and Ausloos, P., Pulse radiolysis of neopentane in the gas phase.

OTHER NBS PUBLICATIONS

Bell, F. C., Wollin, H. F., Editors, Report of the 56th National Conference on Weights and Measures 1971, Nat. Bur. Stand. (U.S.), Spec. Publ. 358, 252 pages (Mar. 1972) $1.50, SD Catalog No. C13.6/3:358.

Bullis, W. M., Editor, Methods of measurement for semiconductor materials, process control, and devices—Quarterly Report, July 1 to September 30, 1971, Nat. Bur. Stand. (U.S.), Tech. Note 717, 52 pages (Apr. 1972) 55 cents, SD Catalog No. C13.46:717.

Burnett, E. D., Corliss, E. L. R., Berendt, R. D., Magnetic recording of acoustic data on audiofrequency tape recorders, Nat. Bur. Stand. (U.S.), Tech. Note 718, 29 pages (Apr. 1972) 40 cents, SD Catalog No. C13.46:718.

Gilbert, P., Building research translation. An investigation of the protection of dwellings from external noise through facade walls, Nat. Bur. Stand. (U.S.), Tech. Note 710-2, 26 pages (Mar. 1972) 35 cents, SD Catalog No. C13.46:710-2.

Haupt, G. W., Schleter, J. C., Eckerle, K. L., The ideal Lovibond color system for CIE standard illuminants A and C shown in three colorimetric systems, Nat. Bur. Stand. (U.S.), Tech. Note 716, 115 pages (Apr. 1972) $1, SD Catalog No. C13.46:716.

Hilten, J. S., Lederer, P. S., Sethian, J., A simple hydraulic sinusoidal pressure calibrator, Nat. Bur. Stand. (U.S.), Tech. Note 720, 27 pages (Apr. 1972) 35 cents, SD Catalog No. C13.46:720.

Hust, J. G., Sparks, L. L., Standard Reference Materials: Thermal conductivity of austenitic stainless steel, SRM 735, from 5 to 280 K, Nat. Bur. Stand. (U.S.), Spec. Publ. 260-35, 22 pages (Apr. 1972) 35 cents, SD Catalog No. C13.10:260-35.

Page, C. H., Vigoureux, P., Editors, The International System of Units (SI), Nat. Bur. Stand. (U.S.), Spec. Publ. 330, 1972 Edition, 45 pages (Apr. 1972) 30 cents, SD Catalog No. C13.10:330/2. Supersedes

NBS Special Publication 330, 1971 Edition.

Schwerdtfeger, W. J., Romanoff, M., NBS papers on underground corrosion of steel piling, 1962-1971. Nat. Bur. Stand. (U.S.), Monogr. 127, 63 pages (Mar. 1972) 65 cents, SD Catalog No. C13.44:127.

Sparks, L. L., Hust, J. G., Standard Reference Materials: Thermoelectric voltage of silver-28 atomic percent gold thermocouple wire, SRM 733, versus common thermocouple materials (between liquid helium and ice fixed points), Nat. Bur. Stand. (U.S.), Spec. Publ. 260-34, 34 pages (Apr. 1972) 40 cents, SD Catalog No. C13.10:260-34.

PUBLICATIONS IN OTHER JOURNALS

This column lists all outside publications by the NBS staff, as soon after issuance as practical. For completeness, earlier references not previously reported may be included from time to time.

Abramowitz, S., Acquista, N., The infrared spectrum of matrix isolated $UO_2(g)$ and its thermodynamic properties, J. Phys. Chem. **76,** No. 5, 648-649 (1972).

Andrews, J. R., An interfacing unit for a 28 psec feedthrough sampling head and a random sampling oscilloscope, Rev. Sci. Instr. **42,** No. 12, 1882-1885 (Dec. 1971).

Arenhövel, H., Danos, M., Williams, H. T., Baryon resonances in nuclei with applications to the two-nucleon system, Nucl. Phys. **A162,** 12-34 (1971).

Berger, M. J., Distribution of absorbed dose around point sources of electrons and beta particles in water and other media, J. Nucl. Med. **9,** MIRD Supplement No. 5, 6-23 (Mar. 1971).

Berger, M. J., Energy deposition by low-energy electrons: Delta-ray effects in track structure, and microdosimetric event-size spectra, Proc. 3d Symp. Microdosimetry, Stresa, Italy, October 18-22, 1971, EUR No. 4810 d-f-e, pp. 157-177 (1972).

Blair, B. E., Letter in response to comments by R. O. Whitaker about the paper, Long-Term Continental U.S. Timing System Via Television Networks, IEEE Spectrum **8,** No. 10, 13 (Oct. 1971).

Bloss, R. L., An extensometer for use as a laboratory standard at temperature to 1500 °C, ISA Trans. **10,** No 3, 242-249 (1971).

Borie, E., Maximon, L. C., Olsen, H., Molecular coherence effects in radiation processes: Bremsstrahlung, Phys. Rev. **A 2,** No. 4, 1443-1449 (Oct. 1970).

Bowen, R. L., Cleek, G. W., A new series of x-ray-opaque reinforcing fillers for composite materials, J. Dental Res. **51,** No. 1, 177-182 (Jan.-Feb. 1972).

Brady, E. L., Branscomb, L. M., Information for a changing society, Science **175,** 961-966 (Mar. 3, 1972).

Branscomb, L. M., Why people fear technology, The Futurist, p. 232 (Dec. 1971).

Brauer, G. M., Termini, D. J., Bonding of bovine enamel to restorative resin: Effect of pretreatment of enamel, J. Dent. Res. **51,** No. 1, 151-160 (Jan.-Feb. 1972).

Carter, J. C., Coyne, J. J., SU(6) Clebsch-Gordan coefficients for the product $35 \otimes 70$, J. Math. Phys. **10,** No. 7, 1204-1210 (July 1969).

Cashion, J. K., Mees, J. L., Eastman, D. E., Simpson, J. A., Kuyatt, C. E., Windowless photoelectron spectrometer for high resolution studies of solids and surfaces, Rev. Sci. Instr. **42,** No. 11, 1670-1674 (Nov. 1971).

Cassinelli, J. P., Hummer, D. G., Radiative transfer in spherically symmetric systems—II. The non-conservative case and linearly polarized radiation, Mon. Notic. Roy. Astron. Soc. **154,** No. 1, 9-21 (Oct. 1971).

Chang, S. S., Bestul, A. B., Heat capacity and thermodynamic properties of O-terphenyl crystal, glass, and liquid, J. Chem. Phys. **56,** No. 1, 503-516 (Jan. 1, 1972).

Cooper, J. W., Kolbenstvedt, H., Differential energy and angular cross sections for ionization by several-hundred-keV electrons: Theory and comparison and experiment, Phys. Rev. **A 5,** No. 2, 677-687 (Feb. 1972).

Coyle, T. D., Ritter, J. J., Organometallic aspects of diboron chemistry, Chapter in Advances in Organometallic Chemistry **10,** 237-272 (Academic Press, New York, N.Y., 1972).

Dalke, J. L., International standards for magnetic materials and components, IEEE Trans. Magnetics MAG—**7,** No. 3, 545-548 (Sept. 1971).

Daney, D. E., Thermal conductivity of solid argon, deuterium, and methane from one-dimensional freezing rates, Cryogenics **11,** No. 4, 290-297 (Aug. 1971).

Danos, M., Fully consistent phase conventions in angular momentum theory, Ann. Phys. **63,** No. 2, 319-334 (Apr. 1971).

de Graaf, L. A., Mozer, B., Structure study of liquid neon by neutron diffraction, J. Chem. Phys. **55,** No. 10, 4967-4973 (Nov. 15, 1971s.

Diller, D. E., The specific heats (C_v) of dense simple fluids, Cryogenics **11,** No. 3, 186-191 (June 1971).

Domalski, E. S., Evaluating experimental data on heats of combustion, J. Chem. Doc. **11,** No. 4, 234-237 (1971).

**Publications with prices and SD Catalog numbers indicated may be purchased directly from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (foreign: one-fourth additional). NBS nonperiodical series are also available from the National Technical Information Service (NTIS), Springfield, Va. 22151 (formerly the Clearinghouse for Federal Scientific and Technical Information). Reprints from outside journals and the NBS Journal of Research may often be obtained directly from the authors.*

U.S. GOVERNMENT PRINTING OFFICE : 1972 OL—467—557